Research Proposal
For 2005 Project Year

I. BASIC INFORMATION

A. TITLE OF PROJECT

Evaluation of Gatewell Modifications at Bonneville Second Powerhouse

B. PROJECT LEADERS

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C. STUDY CODES

BPS-P-00-14 (Title: B2 FGE)

D. DURATION

1 January 2005 – 31 December 2005

E. DATE OF SUBMISSION

August 3, 2004

II. PROJECT SUMMARY

A. GOALS

This study will supplement the hydroacoustic sampling proposed in the 2005 Hydroacoustic Fish Passage Efficiency (FPE) study and will allow us to evaluate effects of gatewell modifications by exploring among-intake variation in fish guidance efficiency (FGE) at Powerhouse 2 (B2). The two studies will provide information on the variation in passage and FGE among units and intakes with and without gatewell modifications, among intake location within units, and among intakes with and without turbine intake extensions (TIEs).

B. OBJECTIVES

1. We will continuously sample one additional intake at units 11, 12, and 15 and two additional intakes at Unit 17 beyond the one randomly selected intake out of three per unit proposed in the 2005 Hydroacoustic FPE study.

2. We will estimate FGE for every intake sampled and explore among-intake variation in data from both studies, as affected by gatewell modifications, location, and the presence or absence of turbine intake extensions (TIEs).

C. METHODOLOGY

We will sample with fixed-aspect hydroacoustic equipment 24 h / day for about 45 days each migration season (spring and summer) to estimate the number of guided and unguided juvenile salmonids passing downstream through sampled intakes in units 11, 12, 15, and 17. These units were selected for sampling because units 11 and 12 usually pass the most fish at B2, and units 15 and 17 are the only intakes with modified gatewell slots. The 2005 Hydroacoustic FPE study will provide samples for one out of the three intakes at every B2 unit. Transducer deployments, aiming angles, and sampling sequences will be the same as those used in 2004. One up-looking and one down-looking transducer deployed on the downstream side of trash racks will sample the vertical distribution of fish immediately upstream of the STS tip. We will estimate the number of guided and unguided fish and the associated variances by intake and hour and sum them with estimates from the Bonneville FPE study to provide estimates for units, the powerhouse, days, and seasons. We also will estimate intake FGE and its variance by hour, day, and season and estimate FGE by turbine unit. Methods for comparing fish passage and FGE among units and intakes will be the same as those used by Ploskey et al. (2003) and are described in more detail later. Conditions that vary among intakes include location, which is affected by distance from the end of B2 and by differences in discharge among intakes of each unit (A > B > C), gatewell modification, and the presence or absence of TIEs. In 2005, as in 2004, TIEs will be present at every other intake from 15A through 18B (i.e., at 15A, 15C, 16B, 17A, 17C, and 18B), but will be removed from all intakes at units 11 through 14 to facilitate flow to the Powerhouse 2 Corner Collector (B2CC) adjacent to Unit 11. Gatewells of all intakes of units 15 and 17 have been modified by increasing the vertical extent of the vertical barrier screen (VBS), reducing VBS mesh size, and adding a turning vane. A 20-ft wide gap-closure device that reduced the vertical gap between the intake ceiling and the top of the STS from about 18 to about 9 inches was added to all modified intakes except Intake 15A. Intakes at units 11-14, 16, and 18 will remain unmodified.

D. RELEVANCE TO THE BIOLOGICAL OPINION

The NMFS 2000 Biological Opinion (NMFS 2000) states under Bonneville Dam Second Powerhouse, Action 67: The Corps shall continue Bonneville Second Powerhouse investigations of measures to improve intake screen fish guidance efficiency and safe passage through the gatewell environment. The consultation goes on to say that since the Second Powerhouse now has a state-of-the-art fish conveyance system with relatively low fish guidance efficiency, the next obvious step is improvement of this guidance system.

III. PROJECT DESCRIPTION

The proposed studies will evaluate effects of gatewell modifications by exploring the variation in fish passage and FGE among intakes relative to structural characteristics (TIE vs. no TIE, modified vs. unmodified gatewell) and intake location. Combined with similar fish passage data from the 2005

Hydroacoustic FPE study, this hydroacoustic sampling will produce a robust data set covering five of six intakes with gatewell modifications, four of six unmodified intakes at two units with the highest fish passage, and one of three intakes at the remaining unmodified units.

A. BACKGROUND

The National Marine Fisheries Service (NMFS) began evaluating FGE at B2 in 1983 after construction of B2 was completed in 1982. Initial measurements of FGE with standard-length STSs were less than 25% for yearling chinook salmon (*Oncorhynchus tshawytscha)* and coho salmon (*0.* kisutch) and approximately 33% for steelhead (*O. mykiss).* These guidance levels were considerably lower than the expected design level of 70% or greater for all species (Krcma et al. 1984).

From 1984 to 1989, the U.S. Army Corps of Engineers (COE) and NMFS tested various design modifications to improve FGE at B2. The results of this research indicated that modifications to increase flows above the STS and smooth flows into and within the turbine intake could substantially increase FGE for yearling chinook salmon during the spring migration (Gessel et al. 1991). Tests in 1985 showed that lowering the STS 0.8 m in conjunction with streamlined trashracks increased FGE to about 40% and the gap-net catch (percent of fish escaping over the STS back into the intake) remained at less than 1%. However, lowering the STS 1.2 m increased the gap-net catch to 12%, which resulted in a decreased FGE of 29% (Gessel et al. 1986). From 1987 to 1989, in tests conducted with a 0.8 m lowered STS, streamlined trashracks and turbine intake extensions (TIEs) installed in Units 11, 12, and 13, FGE ranged from 51 to 74% during 4 - 5 day test series. Based on these results, STSs were lowered 0.8 m and TIEs (in front of every other intake) and streamlined trashracks were installed across the powerhouse in 1991.

In 1993 and 1994, FGE was again measured at B2, and FGE averaged 57% for yearling chinook salmon in Unit 15 with all eight units in operation. With Units 11, 12, 13, 16, 17, and 18 operating, FGE averaged 53% and 32% in units 12 and 17, respectively. During all of these tests, the average gap-net catch for all species combined was less than 1% (Monk et al. 1994, 1995).

Hydroacoustic FGE estimates for all juvenile salmonids in 1996, 1998, and 2000 were similar to estimates reported in the NMFS studies described above, and FGE was lower for end units than for units nearer to the center of the powerhouse. In spring 1996, the three highest FGE estimates were 65% (Unit 12), 52% (Unit 15), and 40% (Unit 13), and the average for all eight units was only 37% (Ploskey et al. 1998). In summer 1996, the average FGE was only 26%, and estimates ranged from 10% at Unit 11 to 42% at Unit 12). In 1998, hydroacoustic estimates of FGE for units 11-13 averaged about 55% in spring and 30% in summer during closed sluice-chute treatments (Ploskey et al. 2001). In 2000, the fish-passage efficiency of Powerhouse 2 based upon sampling of all units was 54% in spring and 35% in summer (Ploskey et al. 2002).

To investigate ways to improve FGE, hydraulic model studies of B2 intakes were conducted. Flows of 270 cfs into the gatewell slot and 215 cfs over the top of the STS were measured, indicating the potential for fish to be lost through the gap as substantially larger than that measured by previous FGE studies, and for possible FGE improvements by increasing flow up into the gatewell slot.

To increase flow from the turbine intake into the gatewell, three modifications were proposed: 1) increase the size of the VBS by partial removal of a concrete beam; 2) install a turning vane just below the picking beam on the STS; and 3) install a GCD on the ceiling intake downstream from the top edge of the STS. To meet new design criteria for salmonid fry established by NMFS, screen mesh openings on the new VBS were decreased to 0.08 inches with a porosity of 44%. These modifications as well as a larger VBS were hydraulic model tested, and gatewell flows of 13.6 m^3/s (480 ft^3/s) and gap flows of 2.5

m^3/s (90 ft^3/s) were measured. Based on these promising results of hydraulic model study, in the spring of 2001 the modifications were installed in Unit 15.

Both FGE and OPE tests were conducted in the B intake gatewell where no TIE was present (Monk et al. 2002). In spring, yearling chinook salmon FGE averaged 71% (SE = 2.5), and FGE for steelhead and coho were >80%. These FGE values were the highest measured at the Second Powerhouse since testing began in the early 1980's, and were 15 to 33% higher than comparable values measured in Unit 15 in 1994. In summer, subyearling chinook salmon FGE averaged 57%, which was 17% higher than earlier measurements. The OPE in 15B for yearling chinook salmon in the spring and for subyearling chinook salmon in the summer was high, 94 and 99%, and the averaged median passage times were 1.6 and 0.8 hours, respectively (Monk et al. 2002). There were no significant differences between Unit 15 and another unmodified unit for either OPE or passage times. During both FGE and OPE tests, descaling and injury rates were low for all species sampled (Monk et al. 2002). During spring testing, average descaling ranged from 2 to 3% for all species with no significant differences between the modified and unmodified units, and no differences between the B and A gatewell (with and without the gap closure device, respectively). During summer testing, descaling rates for subyearling chinook salmon was 2% or less in both units with no significant differences between units.

The hydroacoustic estimate of FGE at Intake 15B in spring 2001 (74.3%) was the highest of any unit sampled at Powerhouse 2. In summer, hydroacoustic FGE was 51%, slightly lower than the 57% estimated by Monk et al. (2002), and FGE was 4% lower than an estimate for Units 14 and did not differ significantly from the estimate for Unit 13. Gatewell slots at units 13 and 14 were not modified like those in Unit 15.

Based on favorable results from netting studies, further testing of these intake modifications in additional units and gatewells was warranted to characterize results across the entire powerhouse and gatewells slots with TIEs. Therefore, in 2002, FGE and OPE tests were conducted in Unit 17, and all three turbine intake slots were monitored to test for potential slot effects. Results from spring 2002 indicate that FGE for yearling chinook salmon averaged 47, 67, and 31% for the A, B, and C slots, respectively. Steelhead FGE averaged 49, 54, and 36%, and coho salmon averaged 51, 71, and 60% for the A, B, and C slots, respectively. The differences in FGE between slots were statistically different for yearling chinook salmon ($P=0.001$), but not for steelhead ($P=0.14$) or coho salmon ($P=0.096$). Although the results from Unit 17 are higher than those observed in previous studies with the unmodified configuration (36% in 1994), they were not as high as Unit 15 in 2001 under a similar configuration. Interestingly, steelhead guidance appeared lower than expected. Fish injury and descaling rates were low throughout the spring. Results from summer 2002 indicate that FGE for subyearling chinook salmon averaged 47 and 57% for the A and B slots, respectively, which is similar to the 57% FGE observed in 15B in 2001. The results from NOAA Fisheries studies in 2002 corroborate findings from 2001 that the gatewell modifications tested improved the level of fish guidance into the gatewells with little, if any, effect on fish condition over the existing configuration. However, the 2002 results also indicate that FGE varies between units and intake slots at B2 and OPE may be more variable under the new configuration.

In 2002, hydroacoustic data showed a strong southern skew in the distribution of fish passage at B2 and this suggested that the corner surface collector scheduled to come on line in 2004 would be highly successful (Ploskey et al. 2003). Southern units passed about 64% and 71% of the fish going through B2 in spring and summer, respectively, and units 11 and 12 accounted for 45.3% and 49% of the total each season. A mobile survey in 1996 showed high fish densities in the eddy upstream of the southern end of B2 (Units 11, 12, and 13) in both seasons (Ploskey et al. 1998). In 1998 when the sluice chute ran as a prototype surface collector, the combined FGE of unit 11-13 and the sluice chute was 35% higher in spring and 60% higher in summer than the FGE of units 11-13 when the sluice chute was closed (Ploskey et al. 2001). In 2001, we also reported a southern skew in the distribution of fish passage at B2 (Ploskey et al. 2002).

In 2002, the B and C slots of B2 units and those intakes between TIES at B2 had significantly higher FGEs than did A slots or intakes behind TIES, respectively, probably because A slots have the highest flow, and TIEs create vortices that funnel fish down the face of the dam where they enter high in the intake and are easily guided. The significance of an interaction term between slot and TIE treatments in a two-way ANOVA suggests that the relations are complex. The B slot of Unit 17 had a higher FGE than did the C slot, and this likely was because the B slot was between two TIES.

The operational priority of units at B2 results in a decrease in B2 FPE when percent spill increases because the end units, which have among the lowest FGEs at B2, keep running while center units with higher FGEs are shut down (Ploskey et al. 2003). Giving operational priority to end units makes sense for attracting adult salmonids to fish ladders during the day, but Ploskey et al. (2003) recommended giving priority to units 13-16 at night when adult passage is minimal and juvenile passage is high. Data suggest that B2 FPE could be increased by as much as 20% by shutting down the end units first at night. The management tactic is only needed when operational control is possible and required high spill levels dictate that some units must be taken off line.

No FGE testing was conducted in 2003, but investigations of FGE are being pursued in 2004. Results to date are encouraging, but the variability observed in FGE between units and intakes suggest that further investigation FGE variation is warranted prior to a decision to permanently install the new configuration in other turbine intakes. There also is a need to evaluate the effect of the B2CC on the FGE of units 11-14 for a second year.

The goal of this study is to supplement the hydroacoustic sampling proposed in the 2005 Hydroacoustic FPE study at Bonneville Dam, and this will allow us to evaluate effects of gatewell modifications by exploring among-intake variation in FGE at B2. The two studies will provide information on the variation in passage and FGE among units and intakes with and without gatewell modifications, among intake location within units, and among intakes with and without turbine intake extensions (TIEs).

B. OBJECTIVES

1. We will continuously sample one additional intake at units 11, 12, and 15 and two additional intakes at Unit 17 beyond the one randomly selected intake out of three per unit proposed in the 2005 Hydroacoustic FPE study.

2. We will estimate FGE for every intake sampled and explore among-intake variation in data from both studies, as affected by gatewell modifications, location, and the presence or absence of turbine intake extensions (TIEs).

C. METHODOLOGY

Statistical Conditions

Conditions that vary among intakes include location, which is affected by distance from the end of B2 and by differences in discharge among intakes of each unit (A > B > C), gatewell modification, and the presence or absence of TIEs. In 2005, as in 2004, TIEs will be present at every other intake from 15A through 18B (i.e., at 15A, 15C, 16B, 17A, 17C, and 18B), but will be removed from all intakes at units 11 through 14 to facilitate flow to the Powerhouse 2 Corner Collector (B2CC) adjacent to Unit 11. Gatewells of all intakes of units 15 and 17 have been modified by increasing the vertical extent of the vertical barrier screen (VBS), reducing VBS mesh size, and adding a turning vane. A 20-ft wide gap-closure device that reduced the vertical dimension gap between the intake ceiling and the top of the STS from about 18 to about 9 inches was added to all modified intakes except Intake 15A. Intakes at units 11-14, 16, and 18 will remain unmodified.

Fixed Hydroacoustics

A hydroacoustic system consists of an echosounder, cables, transducers, an oscilloscope, and a computer system. Echosounder and computer pairs will be plugged into uninterruptible power supplies. An echosounder generates electric signals of specific frequency and amplitude and at the required pulse durations and repetition rates, and cables conduct those transmit signals from the echosounder to transducers and return data signals from the transducers to the echosounder. Transducers convert voltages into sound on transmission and sound into voltages after echoes return to the transducer. The oscilloscopes will be used to display echo voltages and calibration tones as a function of time, and the computer system will control echosounder activity and record data to a hard disk. The 420 kHz, circular, single- or split-beam PAS transducers will be controlled by PAS 103 echosounders and Hydroacoustic Assessments' HARP software running on Pentium-class computers.

Before deployment, all hydroacoustic equipment will be transported to Seattle, Washington, where Precision Acoustic Systems (PAS) will electronically check the echosounders and transducers and calibrate the transducers using a standard transducer. After calibration, we will calculate receiver gains to equalize the output voltages among transducers for on-axis targets ranging in hydroacoustic size from –56 to –36 dB || 1µPa at 1 m. Lengths of fish corresponding to that acoustic size range would be about 1.3 and 11 inches, respectively, for fish insonified within 21° of dorsal aspect (Love 1977). Inputs for receiver-gain calculations include calibration data [i.e., echosounder source levels and 40 log (range) receiver sensitivities for specific transducers and cable lengths] and acquisition equipment data and settings (installed cable lengths, maximum output voltage, and on-axis target strengths of the smallest and largest fish of interest).

We will sample 24 h / day for about 45 days each season (spring and summer) with three single- and one split-beam system at B2 turbines to estimate the number of guided and unguided juvenile salmonids passing downstream through every sampled intake in units 11, 12, 15, and 17. These units were selected for sampling because units 11 and 12 usually pass the most fish at B2, and units 15 and 17 are the only intakes with modified gatewells. Sampling two of three intakes at each of units 11 and 12 will greatly improve precision for the two units with the highest fish passage rates at B2 and for B2 as a whole. Sampling two out of three intakes at Unit 15 and all intakes of Unit 17 will provide precise estimates of FGE for these modified units. There will be 8 single- and 2 split-beam transducers deployed in B2 turbines for this study and 16 single-beam transducers deployed in eight B2 turbine intakes (one out of three intakes at every unit) for the 2005 Hydroacoustic FPE study.

Fixed-aspect hydroacoustic samples will be collected with a pair of transducers deployed on the downstream side of trash racks of intakes to sample the vertical distribution of smolt-sized fish passing immediately upstream of the STS (Figure 1). One transducer of each pair will be mounted at the bottom of the uppermost trash rack and aimed downward to sample unguided juvenile salmon passing below the tip of the STS. The second transducer of each pair will be mounted on the bottom of the fourth trash rack from the top and aimed upward to sample fish passing above the tip of the screen. The location of transducer pairs within intakes will be randomized among north, center, and south positions on the trash racks.

Transducers on each system will be sampled sequentially for 1 minute each to allow a high transmit rate of 23 pings / second. Sequential sampling to maximize pulse repetition rate will be consistent with sampling at B1 turbines and the spillway. The pair of split-beam transducers will be deployed in a randomly selected intake to obtain fish velocity, trajectory, and target strength data for modeling detectability. Acoustic counts for each intake sampled will be expanded spatially using Equation 1 (see <u>Data Processing</u> below).

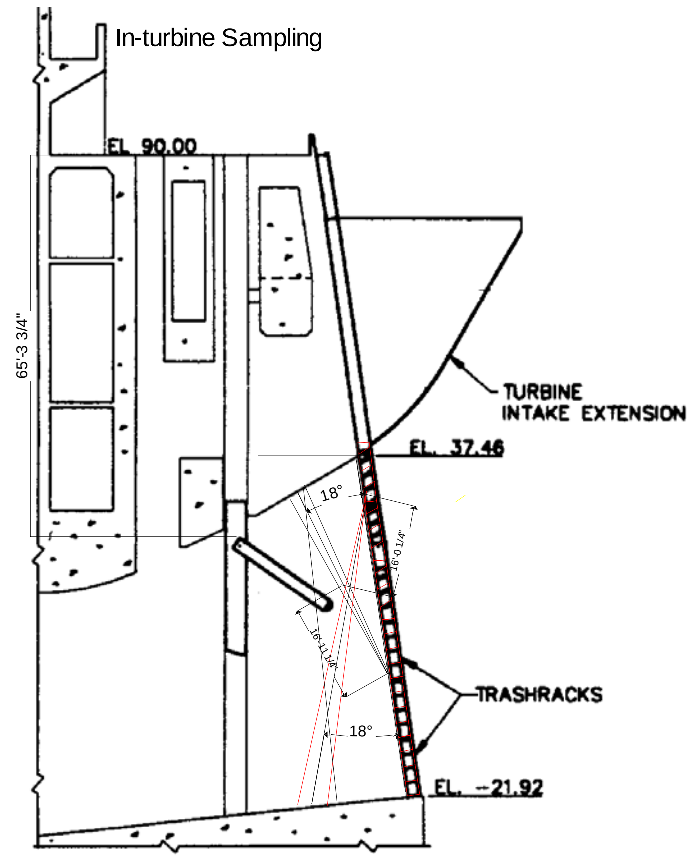

Figure 1. Cross-section view through a Powerhouse-2 turbine intake with a TIE showing hydroacoustic beams for sampling fish passing above and below the submerged traveling screen (STS). Flow into the intake is from right to left. Fish counts are used to estimate fish passage and guidance efficiency. The turbine intake extensions will be present at every other intake from Intake 15A to Intake 18B but will be removed from units 11 through 14 to facilitate flow to the new corner collector adjacent to Unit 11.

Spatially expanded numbers of guided and unguided fish and within-hour variances for each of 7, 10, or 20 1-minute periods per transducer hour will be expanded to a full hour. Expansion of hourly variances at intakes to represent unit variances is described below under <u>Data Processing</u>. Hourly passage estimates and variances for guided and unguided fish will be summed to obtain daily and seasonal estimates for every turbine and then combined to calculate Powerhouse FPE and its variance. Single-beam systems will be sampled 7-10 minutes per hour and the split-beam system will be sampled 20 minutes per hour. The number of samples per hour will vary among systems depending upon the number of transducers that will be slow multiplexed.

Hydroacoustic data from this study and from the B2 portion of the 2005 FPE study will provide a dataset for comparing effects of gatewell modifications (modified unit vs. unmodified units), location among units and among intakes within modified units, and effects of TIEs on FGE. We will use Proc Mixed (SAS) to do the analysis of variance and include repeating Julian day in an AR(1) design to account for autocorrelation within location conditions. We will test for differences among all pairs of least-square means using the LSMEAN statement with Tukey-Kramer adjustment for the unbalance design each season. Unbalanced conditions result from varying dam operations among units.

Acoustic counts for each intake sampled will be expanded spatially using Equation 1 below. Spatially expanded numbers of guided and unguided fish and within-hour variances will be expanded to a full hour. Hourly passage estimates and variances for guided and unguided fish will be summed to obtain daily and seasonal estimates of fish passage, and FGE will be calculated as the sum of guided fish divided by the sum of guided and unguided fish for each time period of interest.

Acoustic counts of juvenile salmon will be expanded based upon the ratio of intake width to beam diameter at the range of detection:

$$Exp\_Num = \frac{IW}{(Mid\_R \cdot Tan(EBA/2) \cdot 2)} \qquad 1.0$$

where IW is opening width in m, Mid_R is the mid-point range of a trace in m, Tan is the tangent, and EBA is effective-beam angle in degrees. Effective beam angle depends upon the detectability of fish of different sizes in the acoustic beam and is a function of nominal beam width and ping rate (pings / sec) as well as fish size, aspect, trajectory, velocity, and range. We will model detectability to determine effective beam widths by range in spring and summer using fish velocity data (by 1- m strata) and target strength data from the split-beam transducers. These data and other hydroacoustic-acquisition data (e.g., beam tilt, ping rate, target-strength threshold, number of echoes, and maximum ping gaps) will be entered into a detectability model, which calculates an effective beam angle as a function of range based upon 1 million fish detections in the modeled beam. The EBA will be entered into Equation 1 to calculate a range dependent factor for expanded the count of every tracked fish to the width of the turbine intake.

Schedule

The PNNL will install hydroacoustic transducers in February and sample continuously through the Spring Creek Hatchery release in March and from about 20 April through 15 July 2002. Preliminary findings will be reported by the end of August for spring results and the end of October for summer results. A verbal presentation will be made in November, and draft final report will be completed by 31 January 2005, and the final report will be printed within 60 days after all reviewer comments have been received.

D. FACILITIES AND EQUIPMENT

All hydroacoustic electronics and data-acquisition computers are available. Some armored and split-beam cables deployed for 7-8 months in 2004 will likely need to be replaced for 2005 sampling and some transducers may require repair.

E. IMPACTS

The acoustic frequencies transmitted in this study are above those that can be injure salmon. We will take care to make mounts for the acoustic camera and hydroacoustic transducers as hydraulically efficient as possible and without sharp edges that might injure fish.

Other Research

We plan to coordinate closely with other researchers to avoid conflicts and to assure that studies are cost efficient and complementary.

Project

Installation and removal of hydroacoustic equipment will require rigger support and use of the gantry and TIE cranes, respectively.

F. COLLABORATIVE ARRANGEMENTS AND/OR SUB-CONTRACTS

The PNNL plans to subcontract with BAE, Inc. to supplement staffing with experienced personnel.

IV. LIST OF KEY PERSONNEL AND PROJECT DUTIES

Gene R. Ploskey (PNNL)	Senior Scientist and Principal Investigator – all aspects
Mark Weiland (PNNL)	Senior Scientist and co-PI – all aspects
Carl Schilt (BAE)	Scientist – analysis and write up
Kyle Bouchard	Senior Technician – equipment maintenance, installation, and removal
Deborah Patterson	Data management and automated processing
Technicians	Equipment installation, cable routing, equipment removal, and manual tracking

V. TECHNOLOGY TRANSFER

Information acquired during the proposed work will be transferred in the form of written and oral research reports. A presentation will be made at the Corps' annual Anadromous Fish Evaluation Program Review. Draft reports will be provided to the COE by 31 January 2005, and the final reports will be completed within 60 days after appropriate review. Technology transfer activities may also include presentation of research results at regional or national fisheries symposia, or publication of results in a scientific journal.

VI. LIST OF REFERENCES

Gessel, M. H. L. G. Gilbreath, W. D. Muir, and R. F. Krcma. 1986. Evaluation of the juvenile collection and bypass system at Bonneville Dam - 1985. Report to U.S. Army Corps of Engineers, Contract DACW57-85-H-0001, 64 p. plus Appendix. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Gessel, M. H., J. G. Williams, D. A. Brege, R. F. Krcma, and D. R. Chambers. 1991. Juvenile salmonid guidance at Bonneville Dam Second Powerhouse, Columbia River, 1983-1989. N. Am. J. Fish. Manage. 11:400-412.

Krcma, R.F., M. H. Gessel, W. D. Muir, C. S. McCutcheon, L. G. Gilbreath, and B. H. Monk. 1984. Evaluation of the juvenile collection and bypass system at Bonneville Dam - 1983. Report to U.S. Army Corps of Engineers, Contract DACW57-83-F-0315, 56 p. plus Appendix. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Love, R. H. 1977. Target strength of an individual fish at any aspect. Journal of the Acoustical Society of America 62(6):1397-1403.

Monk, B. H., B. P. Sandford, and D. B. Dey. 1994. Evaluation of the fish guidance efficiency of submersible traveling screens and other modifications at Bonneville Dam second Powerhouse, 1993. Report to U.S. Army Corps of Engineers, Delivery Order E96930031, 26 p. plus Appendix. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA. 98112-2097).

Monk, B. H., B.P. Sandford, and D.B. Dey. 1995. Evaluation of the fish guidance efficiency of submersible traveling screens and other modifications at Bonneville Dam second Powerhouse, 1994. Report to U.S. Army Corps of Engineers, Delivery Order E96940027, 15 p. plus Appendix. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA. 98112-2097).

Monk, B. H., R. F. Absolon, B. P. Sandford, and J. W. Ferguson. 2002. Evaluation of intake modifications at Bonneville Dam Second Powerhouse, 2001. Report of Research by the Fish Ecology Division, N. W. Fisheries Science Center, NOAA Fisheries for the U. S. Army Engineer District, Portland, OR.

Monk, B., J. W. Ferguson, and B. Sandford. 2004. Evaluation of intake modifications at Bonneville Dam Second Powerhouse, 2002. Draft Report to U.S. Army Corps of Engineers. Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA. 98112-2097.

National Marine Fisheries Service. 2000. Endangered Species Act -Section 7 Consultation conducted by National Marine Fisheries Service. Biological Opinion - Reinitiation of Consultation on Operation of the Federal Columbia River Power System, Including the Juvenile Fish Transportation Program, and 19 Bureau of Reclamation Projects in the Columbia Basin. Date issued December 21, 2000.

Ploskey, G. R., L. R. Lawrence, P. N. Johnson, W. T. Nagy, and M. G. Burczynski. 1998. Hydroacoustic evaluations of juvenile salmonid passage at Bonneville Dam including surface-collection simulations. Technical Report EL-98-4, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Ploskey, G. R., W. T. Nagy, L. R. Lawrence, D. S. Patterson, C. R. Schilt, P. N. Johnson, and J. R. Skalski. 2001. Hydroacoustic evaluation of juvenile salmonid passage through experimental routes at Bonneville Dam in 1998. ERDC/EL TR-01-2, U. S. Army Engineer Research and Development Center, Vicksburg, MS.

Ploskey, G. R., C. R. Schilt, M. E. Hanks, J. R. Skalski, W. T. Nagy, P. N. Johnson, D. S. Patterson, J. Kim, L. R. Lawrence. 2002. Hydroacoustic Evaluation of Fish Passage Efficiency Through Bonneville Dam in 2000. ERDC/EL TR-02-8, U. S. Army Engineer Research and Development Center, Vicksburg, MS.

Ploskey, G. R., C. R. Schilt, J. Kim, C. W. Escher, J. R. Skalski. 2003. Hydroacoustic evaluation of fish passage through Bonneville Dam in 2002. Technical Report PNNL-14356 to the U. S. Army Engineer District, Portland. 111 pp. and Appendices.

VII. BUDGET

A detailed budget will be provided under a separate cover.